INTRODUCTION TO MICROECONOMIC THEORY

1. THE SCIENCE OF ECONOMICS

Economics is the study of *choice* under conditions of *scarcity* or the study of *choice* with *constraints*. Specifically we say that economics is the study of how individuals and societies choose to employ *scarce* resources that could have alternative uses to produce products and services, and distribute them, now or in the future, among various individuals and groups in society.

2. AGENTS (ACTORS) AND PREFERENCES

2.1. **Unit of analysis and preferences.** The *fundamental unit of analysis* in economics is the *economic agent*. Typically this agent is an individual consumer or a firm. The agent might also be the manager of a public utility, the stockholders of a corporation, a government policymaker and so on.

The underlying assumption in economic analysis is that all economic agents possess a *preference ordering* which allows them to rank alternative states of the world.

The *behavioral* assumption in economics is that all agents make choices consistent with these underlying preferences.

2.2. **Definition of a competitive agent.** A buyer or seller (agent) is said to be competitive if the agent assumes or believes that the market price of a product is given and that the agent's actions do not influence the market price or opportunities for exchange.

2.3. **Consumer example.**

2.3.1. *Products as objects of choice.* Consider a simple case where consumers are endowed with a certain amount of money income. Assume that final products and services are the only objects of choice available to an individual in the economic system. Assume that these are the various products and services available for purchase in the market. Assume that the number of products is finite and equal to L (ℓ =1, ..., L). A product vector is a list of the amounts of the various products:

$$ x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_L \end{bmatrix} $$

The product bundle x can be viewed as a point in R^L.

2.3.2. *Consumption sets.* The consumption set is a subset of the product space R^L, denoted by $X^L \subset R^L$, whose elements are the consumption bundles that the individual can conceivably consume given the physical constraints imposed by the environment. We typically assume that the consumption set is X = R_+^L = {x $\in$ R^L: $x_\ell \geq 0$ for ℓ = 1, ... , L}.

2.3.3. *Prices.* We will assume that all L products are traded in the market at dollar prices that are publicly quoted. How they are determined will be discussed later. The prices are represented by a price vector

$$
p = \begin{bmatrix} p_1 \\ p_2 \\ \vdots \\ p_L \end{bmatrix} \in R^L
$$

For now assume that all prices are strictly positive, i.e. $p_\ell >> 0$. We will also assume that all consumers are price takers in the sense that they cannot influence the price at which they buy or sell a product.

2.3.4. *Income.* Assume that each consumer has wealth equal to m_i or the representative consumer has wealth m.

2.3.5. *Affordable consumption bundles.* We say that a consumption bundle x is affordable for the representative consumer if

$$
p\,x = p_1\,x_1 + p_2\,x_2 + \cdots + p_L\,x_L \le m \tag{1}
$$

If x is also an element of R_+^L , then the set of feasible consumption bundles is $x \in R_+^L : px \le m$. This is called a Walrasian budget set and is denoted $B_{p,m}$.

2.3.6. *Preferences.* We assume a preference relation over products $\succeq$ with the following properties
   1: complete in that for all $x_1, x_2 \in X$, we have $x_1 \succeq x_2$ or $x_2 \succeq x_1$ (or both)
   2: transitive in that $\forall x_1, x_2, x_3 \in X$, if $x_1 \succeq x_2$ and $x_2 \succeq x_3$ then $x_1 \succeq x_3$.
   3: locally nonsatiated in that for every $x_1 \varepsilon$ X and every $\varepsilon > 0$, there is $x_2 \in X$ such that $||x_2 - x_1 \le \varepsilon||$ and $x_2 \succeq x_1$.
   4: continuous in that for any sequence of pairs

$$
\{ (x_1^n,\ x_2^n) \}_{n=1}^\infty \ with \ x_1^n \succeq\ x_2^n \forall\ n,
$$
$$
x_1 = \lim_{n \to \infty} x_1^n,\ and\ x_2 = \lim_{n \to \infty} x_2^n,
$$
$$
we\ have\ x_1 \succeq x_2.
$$

2.3.7. *Existence of a utility function.* Based on the preferences defined in 2.3.6, there exists a continuous utility function v(x) that represents $\succeq$ in the sense that $x_1 \succeq x_2$ iff $v(x_1) \ge v(x_2)$.

2.3.8. *The utility maximization problem.* The utility maximization problem representing the choice problem for the consumer is then as follows

$$
\max_{x \ge 0} u(x)
$$
$$
s.t. \sum_{i=n}^{n} p_i x_i\ \le\ m \tag{2}
$$

where we assume that p $>> 0$, m > 0 and X = R_+^L .

If the problem in equation 2 is solved using Lagrangian multiplier techniques, the first order conditions are

$$\frac{\partial v}{\partial x_i} - \lambda p_i = 0, \quad i = 1, 2, \ldots, n \tag{3a}$$

$$-\Sigma_{i=1}^n p_i x_i + m = 0 \tag{3b}$$

Ratios of any of the equations in 3a will give

$$\frac{\frac{\partial v}{\partial x_i}}{\frac{\partial v}{\partial x_j}} = \frac{p_i}{p_j}$$

$$\Rightarrow \frac{\frac{\partial v}{\partial x_i}}{p_i} = \frac{\frac{\partial v}{\partial x_j}}{p_j}$$

$$\Rightarrow \frac{\frac{\partial v}{\partial x_i}}{p_i} = \frac{\frac{\partial v}{\partial x_1}}{p_1} \tag{4}$$

$$\Rightarrow \frac{\frac{\partial v}{\partial x_j}}{p_j} = \frac{\frac{\partial v}{\partial x_1}}{p_1}$$

$$\Rightarrow \frac{\partial v}{\partial x_i} = \frac{p_i}{p_1} \frac{\partial v}{\partial x_1}$$

This implies that the ratio of marginal utilities is equal to the price ratio and that the ratio of marginal utility to price is the same for all goods.

2.3.9. *Properties of the solution.* The solution to 2 is given by x(p,m) and has the following properties

    a: homogeneity: $x(\lambda p, \lambda m) = x(p, m)$

    b: Walras law: $p x = m \, \forall \, x \, \epsilon \, x(p, m)$

    c: convexity: If $\succeq$ is convex , so that u(·) is quasi-concave, then x(p,m) is a convex set

    d: uniqueness: If $\succeq$ is strictly convex, so that u(·) is strictly quasi-concave, then x(p,m) consists of a single element

2.3.10. *Aggregation.* For the time being we will assume that there exists an aggregate demand function for the I consumers in the economy as follows

$$x(p, m_1, m_2, \cdots, m_I) = \Sigma_{i=1}^{I} x_i(p, m_i) = x(p, \Sigma_i m_i) \tag{5}$$

In equation 5, x is a vector containing the total amount demanded of each of the products in the economy.

3. RESOURCES

Resources are anything that can be used directly or indirectly to satisfy human wants. Products and services are resources as are natural and human resources. We sometimes call resources *factors of production* because they are the things we use to produce products and services for consumption. We usually talk about three types of resources:

    1: *land*, which is physical space together with the natural resources found above or beneath it.

    2: *labor*, which is the time human beings spend producing products and services

    3: *capital*, which is a long-lasting resource (not used up in the process) used to produce products and services

Capital can be divided into two types:

1: physical capital, which is tools, machines, buildings, terraces, natural gas deposits, forests, rivers, and so forth

2: human capital, which is the natural abilities, skills, and training of labor

4. PRODUCTION SYSTEMS, PRODUCTS, SERVICES AND FACTORS

4.1. **Production system or technology.** A **production technology** is a description of the set of outputs that can be produced by a given set of factors of production or inputs using a given method of production or production process.

4.2. **Factors of production.** A **factor of production (input)** is a product or service that is employed in the production process.

4.3. **Expendable factors of production. Expendable factors of production** are raw materials, or produced factors that are completely used up or consumed during a single production period. Examples might include gasoline, seed, iron ore, thread and cleaning fluid.

4.4. **Capital. Capital** is a stock that is not used up during a single production period, provides services over time, and retains a unique identity. Examples include machinery, buildings, equipment, land, stocks of natural resources, production rights, and human capital.

4.5. **Capital services. Capital services** are the flow of productive services that can be obtained from a given capital stock during a production period. They arise from a specific item of capital rather than from a production process. It is usually possible to separate the right to use services from ownership of the capital good. For example, one may hire the services of a backhoe to dig a trench, a laborer (with embodied human capital) to flip burgers, or land to grow corn.

5. FIRMS

5.1. **Definition of a neoclassical firm.** A neoclassical firm is an organization that **controls** the transformation of **inputs** (resources it owns or purchases) into **outputs or products** (valued products that it sells) and **earns** the difference between what it receives in revenue and what it spends on inputs.

5.2. **Production technologies: inputs and outputs.**

5.2.1. *Technology sets.* The technology set for a given production process is defined as

$$T = \{(x, y) : x \in R_+^n, y \in R_+^m : x \ can \ produce \ y \ \} \tag{6}$$

where x is a vector of inputs and y is a vector of outputs. The set consists of those combinations of x and y such that y can be produced from the given x. We assume that n + m = L, the number of products in the economy. For some technologies the ith factor in the economy may be an input, for other technologies it may be an output, and for some technologies it could be either. Consider for example a firm which produces steel ingots which are then cast into a variety of forms, plates, coils, bars, sheets and so on. The firm could purchase these ingots from another firm or sell ingots to a different firm. Though this is not likely due to transportation costs, the net flow of ingots to and from the technology could be different in different periods. Or consider a corn farmer who also feeds cattle. The individual could sell excess corn on the market, or purchase corn to feed more cattle.

5.2.2. *Returns from the production technology.* The returns to a particular production plan are given by the revenue obtained from the plan minus the costs of the inputs or

$$\pi = \Sigma_{j=1}^{m} p_j\, y_j - \Sigma_{i=1}^{n}\, w_i\, x_i \qquad (7)$$

where p_j is the price of the jth output and w_i is the price of the ith input.

A neoclassical firm is then an organization that controls one or more production technologies and receives the returns from implementing those technologies in a particular way, paying for the inputs, and receiving the revenue from the outputs or products.

5.3. **Objectives of a firm.** We typically assume that a firm exists to make money. Such firms are called *for-profit* firms. Given this assumption we can set up the firm level decision problem as maximizing the returns from the technologies controlled by the firm taking into account the demand for final consumption products, opportunities for buying and selling products from other firms, and the actions of other firms in the markets in which the firm participates. In perfectly competitive markets this means the firm will take prices as given and choose the levels of inputs and outputs that maximize profits. In the case where the firm controls a single technology within a vertical chain the problem can be written

$$\max_{x,\, y} \left[p\, y - \Sigma_{i=1}^{n}\, w_i\, x_i \right]\ such\ that\ \left[(x, y)\, \epsilon\, T \right] \qquad (8)$$

If the firm controls more than one production technology it would take into account the interactions between the technologies and the overall profits from the group of technologies. A firm may choose to acquire more technologies and control more steps in the chain if that will lead to lower costs of producing and marketing the product within the chain.

The solutions to 8 are given by x(p,w) and y(p,w). The solutions have the following properties
  a: homogeneity: y = (tp, tw) = y(p, w) and x_i(tp, tw) = x_i (p, w)
  b: convexity:

$$\frac{\partial y\,(p,\ w)}{\partial p}\ \geq\ 0$$

$$\frac{\partial x_i}{\partial w_i}\ \leq\ 0$$

  d: cross price derivatives: With suitable differentiability properties,

$$\frac{\partial y}{\partial w_i}\ =\ -\,\frac{\partial x_i}{\partial p}$$

$$\frac{\partial x_i}{\partial w_j}\ =\ \frac{\partial x_j}{\partial w_i}$$

5.3.1. *Aggregation.* Suppose there are J firms in the economy, each specified by a production technology T_1, T_2, ..., T_J. For the time being we will assume that there exists an aggregate supply function for the J firms in the economy as follows

$$y\,(p,\ w)\ = \Sigma_{j=1}^{J}\, y_j(p,\ w)$$

$$= \{y \in R^m : y = \sum_{j=1}^{J} y_j \text{ for some } y_j \in y_j(p, w), j = 1, 2, \ldots, J\} \qquad (9)$$

In equation 9, y is a vector containing the total supplied by firms of each of the products in the economy.

5.4. **Implications of the definition of a neoclassical firm.** Some have said that the neoclassical definition of the firm treats the firm as synonymous with the technology. The firm is a engineering construct that specifies how inputs and outputs are related, assumes a decision rule for choosing the inputs and outputs subject to the technology and earns any returns that come from this process. In reality, firms must deal with many complex human challenges, such as creating incentives, and coping with incomplete information. The neoclassical model of a firm views labor as an input like any other. However, labor is different, since the workers must be motivated to work effectively (supply the input purchased). Supplying effective incentives may be difficult, because the employer cannot have complete information about the effort a worker is exerting. Such issues will be ignored for the present.

6. Economic environment and "outcomes" of the economic system

6.1. **Economic system (economy).** One possible definition of an economic system considers it as a collection of consumers, firms, and products and the environment (defined in section 6.2) in which they make decisions. We summarize this information as follows.

1: There are I consumers numbered $1, 2, \ldots, I$, each characterized by a consumption set $X_i \subset R^L$ and a preference relation $\succeq_i$ defined on X_i

2: There are J firms numbered $1, 2, \ldots, J$, each characterized by a production technology $T_j \in R^L$.

3: There is an initial endowment of factors in the economy. This is given by a vector $\bar{\omega} = (\bar{\omega}_1, \bar{\omega}_2, \ldots, \bar{\omega}_L) \in R^L$.

4: Each consumer has an initial endowment vector of products $\omega_i \in R^L$ where $\bar{\omega} = \sum_i^I \omega_i$.

5: Each consumer has a claim to a share $\theta_{ij} \in [0, 1]$ of the profits of firm j where $\sum_i^I \theta_{ij} = 1$ for every firm j.

6: All agents in the economy are assumed to be competitive.

7: All production, exchange, and consumption between agents takes place within the a set of institutionalized rules, procedures, traditions and other factors that make up the economic environment.

6.2. **The economic environment.** The actions taken by any agent depend on the opportunities presented to that agent. These opportunities depend on the *economic environment* of the agent. This environment is determined (constrained) by:

1: basic physical and biological properties of the world in which the agent lives,

2: the man-made technologies available and in use,

3: the actions of other agents,

4: the institutional framework of the economic system, and

5: other legal, social or moral limits on choice,

6: uncertain or stochastic factors that influence other parts of the environment.

6.3. **Outcomes ensuing for each agent in the system.** Outcomes are the things that happen in an economic system. An outcome might be that you receive your first paycheck and spend it all on a new wheel for your bike. Another outcome might be that you quit your job in Des Moines, IA, take a job in Denver, CO, move there, receive one paycheck and then get fired.

Given a particular economic environment and a set of choices (or choice rules) for each agent, we can determine the outcome for each agent depending on the actions of all the agents in the system and a particular realization of the random factors that influence the system.

The outcome of the economic system is thus not predetermined but depends on random events, individual choices, and other agents reactions to those individual choices.

The joint actions of economic agents influence the outcome of the economic system. The economy might be viewed as a complex system in which the choices of each agent influence the state and direction of the system. For example, if a switchman at a railway yard sends two trains in the same direction on the same track there is high probability that lives and property will be forfeited, independent of most other choices in the system. Alternatively, if all consumers refuse to buy products made from trees cut from forests with spotted owls, there will be changes in the pattern and costs of lumber worldwide. At a more microeconomic level, if a person decides to work less hours in order to enjoy life more, the amount of goods she will consume will probably fall. Or if a firm chooses to produce less goods, it may have lower profits. But on the other hand it may have higher than average profits due to a positive production or price shock.

Given the joint actions of economic agents, the state of the economy is not deterministic but stochastic. We often assume that there are no random factors in the economy to simplify analysis. This is called economics under certainty. The economics of uncertainty is a study of the nature of the randomness of the economic environment and its impact on individual choice, individual welfare and overall economic performance.

7. DEFINITION OF A MARKET

7.1. **Definition 1 of a market.** A market is defined as **one particular product** (or the product and its close substitutes and complements) and the economic interactions of **individuals** who **own, produce, trade and consume** this product. This definition is imprecise since it not always obvious how generally the product should be defined. In a pure sense the product should be homogeneous. **Homogeneity is usually defined in terms of form, place, time, and possession.** For example in some cases the product may be exactly the same as far as physical characteristics (form), but may differ as far as its location (place) or its time of availability. In many cases close substitutes must be considered in analyzing a market as with Coke and Pepsi. But the extent to which close substitutes must be considered is not always this obvious, as for example, chicken versus beef in considering meat consumption. In general we will assume that a market under consideration is well defined and involves either a homogeneous product or a group of differentiated products that are **fairly close substitutes (or complements) for at least one product in the group and have limited interaction with the rest of the economy.** Thus we can speak of the market for corn, or the market for unskilled labor in Detroit, or the market for cocaine in Reno, Nevada.

7.2. **Definition 2 of a market.** A market is often defined as a **situation** in which **buyers and sellers** can negotiate the **exchange** of some product or products. One might say that it is a group of buyers and sellers with facilities for trading. A market may be located in a specific place such as the local farmers' market but can just as easily operate without all participants or the product in question being present such as the market for corn (including futures) or the market for used cars. The traders may be spread over a whole city, region, country or the world as long as they are in close communication with each other and can convey the necessary information to promote exchange.

This definition considers a market as a general means to facilitate the exchange of products and services.

7.3. **Product differentiation and market definition.** The product under consideration in a given market is usually assumed to be homogeneous or close to it. **A product that is not homogeneous is referred to as differentiated.** Differentiated products usually differ by form, place, time or possession. These differences are sometimes called form, time, place and possession utilities though they are not assumed to be additive.

7.3.1. *Form utility.* **Products that differ physically are said to differ in form**. For example, Pepsi and Coke are two similar cola products but they differ (at least to sensitive mouths) physically enough that they are not considered the same product. Similarly with hamburgers, a Big Mac and a Burger King Whooper are physically different. Form utility may also be in the eye of the beholder. Processing is a common way to change the form utility of a product.

7.3.2. *Place utility.* Speaking of **place and time utility** Marshall [1, p. 113] specifies that "the more nearly perfect the market is, the stronger is the tendency for the same price to be paid for the same thing at the same time in all parts of the market; but of course if the market is large, allowance must be made for the expense of delivering the products to different purchasers; each of whom must be supposed to pay in addition to the market price a special charge on account of delivery." **Place utility** is defined as the difference (to a single consumer as an argument in the utility function or in value in general equilibrium) in an otherwise homogeneous product that occurs because of the **product's physical location or circumstance**. Transportation is the most common way to change the place utility of a product.

7.3.3. *Time utility.* In addition to differences such as those based on location, a product may trade at different prices or terms based on its date of delivery as evidenced by the pattern of cattle futures prices or the term structure of interest rates. **Time utility** is defined as the difference in an otherwise homogeneous product that occurs because of the **time at which the product will be available for delivery**. Storage and futures or forward contracts are the most common way to change the time utility of a product.

7.3.4. *Possession utility.* In an advanced economy where legal titles and contract terms are important, the exact rights conveyed with the product may be important. Often the title to delivery of a product will specify certain terms such as time of payment, limited liability, ability to return the product if defective, ties to other products or actions such as agreement to purchase additional product, pricing based on some index, etc. All of these terms differentiate an otherwise homogeneous product. **Possession utility** is defined as the difference in an otherwise homogenous product that occurs because of the **terms and conditions of sale and transfer of title**.

7.3.5. *Vertical chains.* The process that begins with the acquisition of raw materials and ends with the distribution and sale of finished products to a consumer is known as a **vertical chain**. A vertical chain may be made up of a large number of firms using different or the same technologies or a single firm that turns raw materials into a finished product ready for final consumption.

7.3.6. *Market channels.* A **market channel** is a description of the set of firms or activities that add place, time, form or possession utility to a product as it is transformed from a raw material or intermediate product into one that is purchased by another firm or final consumers. A broadly defined market channel is synonymous with a vertical chain while a more narrowly defined one may be a subset of a particular chain such as the market channel for new cars (manufacturers inventory to retail sale) or the market channel for fresh sweet corn sold at a roadside stand.

8. MARKET STRUCTURES AND EQUILIBRIUM

8.1. **Equilibrium (loose definition).** A set of prices (p,w) and allocations of products to consumers and firms is said to be an equilibrium if

1: For every firm the set of inputs used and outputs produced maximize profit at those prices given the firms technology.

2: For each consumer the consumption bundle is maximal for $\succeq_i$ in the budget set defined by the initial endowment (valued at the equilibrium prices) and their share of the profits of the J firms in the economy.

3: The total consumption of products by consumers is equal to initial endowments plus the net output of firms.

8.2. **Definition of market structure. Market structure** refers to all features of a market that affect the behavior and performance of firms (and consumers) in that market. The keys factors in defining a market structure are the short run and long run objectives of buyers and sellers in the market, their beliefs about the ability of themselves and others to set prices, the technologies they employ, the amount of information available to them about the product and about each other, the degree of coordination or noncooperation they may exhibit, the extent of entry and exit barriers, and the degree of product differentiation.

9. POSITIVE ECONOMIC ANALYSIS

9.1. **Definition.** Understanding, describing and predicting economic behavior.

9.2. **Examples.**

1: What determines the price of rice?
2: What determines the price of coal?
3: What happens to oil output when price rises?

9.3. **Hypothesis testing and positive analysis.** The hallmark of positive economics is the construction of various hypotheses about economic behavior and the subjection of these hypotheses to empirical verification.

10. NORMATIVE ECONOMIC ANALYSIS

10.1. **Definitions.**

1: Determining what "ought to be".
2: Using resources optimally so as to achieve the maximum well-being for individuals in society.

There are usually problems of measuring preferences in normative analysis.

10.2. **Examples.**

1: Should we build a bridge over the Grand Canyon?
2: Should a tariff on textiles be removed?
3: Should the government compensate labor displaced by tomato harvesters?
4: Should a specific farmer (Jones, Smith or Nakagawa) plant corn or wheat?

11. Conditional normative analysis

11.1. **Definition.** Understanding, describing and predicting economic behavior by assuming that economic agents optimize (or maximize their preferences) according to some set of assumptions or rule, determining their optimal response given that rule, and then using these derived expressions to test various positive hypotheses.

11.2. **Examples.**

1: Estimate a production function for corn, determine the supply of corn as a function of corn price, and then predict the corn supply elasticity.

2: Develop a nonlinear programming model of an electricity firm and the market in which it operates including a representation of transmission grids, feedback, an auction market for electricity, final demand, government policy constraints, and so forth. Change one of the policy constraints and use the model results to predict the actual response to a change in policy.

3: Describe the investment decision of the firm as an optimal control problem, determine the optimum investment rule, and then use this rule to predict response to a change in the interest rate.

References

[1] Marshall, A. *Principles of Economics* 8$^{\text{th}}$ Edition. London: Macmillan, 1946.